DOCUMENT RESUME

ED 277 731 TM 870 007

AUTHOR Tanner, David E.
TITLE Achievement as a Function of Abstractness and Cognitive Level.
PUB DATE [86]
NOTE 23p.; Paper presented at the Annual Meeting of the American Educational Research Association (67th, San Francisco, CA, April 16-20, 1986).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Abstract Reasoning; *Achievement Tests; Analysis of Variance; *Cognitive Processes; College Students; Difficulty Level; Higher Education; *Item Analysis; Multiple Choice Tests; *Recall (Psychology); Scores; Test Construction; Test Items
IDENTIFIERS *Blooms Taxonomy

ABSTRACT

A multiple choice achievement test was constructed in which both cognitive level and degree of abstractness were controlled. Subjects were 75 students from a major university in the Southwest. A group of 13 judges, also university students, classified the concepts for degree of abstractness. Results indicated that both cognitive level and degree of abstractness accounted for a significant amount of variance in subjects' test scores. Furthermore, the interaction of the two main effects was significant. The presence of this interaction may help explain the inconsistency of findings in research dealing with the cognitive level of questions/test items and learner achievement. Data tables and five pages of bibliographic references are appended. (Author/JAZ)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED277731

Achievement as a Function of Abstractness and Cognitive Level

David E. Tanner

California State University, Fresno

Abstract

A multiple choice achievement test was constructed in which both cognitive level and degree of abstractness were controlled. Results from 75 subjects indicated that both cognitive level and degree of abstractness accounted for a significant amount of variance in subjects' test scores. Furthermore, the interaction of the two main effects was significant. The presence of this interaction may help explain the inconsistency of findings in research dealing with the cognitive level of questions/test items and learner achievement.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

D. E. Tanner

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

TM 820 007

The question has been an important pedagogical tool for several centuries, but only in the last twenty-five years has the effect of questioning on learning been made the object of systematic study. It was after hiearchically structured, cognitive taxonomies were developed by Bloom and his associates (1956), Sanders (1966), and others that questions were classified by cognitive demand. The classification allowed different types of questions to be studied in terms of their effect on student learning.

A common assumption in education has been that one's ability to deal with greater cognitive complexity is an indication of a higher level of understanding. It seemed to follow that those questions which demanded more than recall would be more beneficial to students than questions which emphasized only rote. This assumption predates the use of the taxonomies. Long before such taxonomies were used, educators decried the predominance of recall-level questions by teachers (Corey, 1940; Haynes, 1935; Stevens, 1912).

Results from attempts to empirically validate the facilitative effect that the use of higher cognitive level questions has on student achievement have been inconsistent, however. Depending upon the study considered, support can be found for each of the following conclusions:

1. Asking students higher-order questions serves to enhance achievement (Buggey, 1971; Redfield & Rousseau, 1981)
2. Asking students higher-order questions retards achievement (Beseda, 1973; Mamary, 1976)

3. Asking students higher-order questions has no impact on achievement (Hunkins, 1969; Winne, 1979)

Notwithstanding inconsistent research results, the idea that learners benefit from greater cognitive complexity has substantial intuitive appeal and remains pervasive in the literature. Attempts to explain the results have included general criticisms of research techniques (Dunkin & Biddle, 1974; Winne, 1979), objections to the assumption that the entire classroom will benefit from a higher-order question asked of a single student (Andre, 1979), and the suggestion that the low cognitive development of subjects may preclude positive results (Martikean, 1973; Savage, 1972).

The Analysis of a Single Dimension Reconsidered

Some time ago Solomon (1970) studied the relationship between cognitive level and student achievement and noted that perhaps educational tasks are viewed too simply. He suggested that to understand the complexity of educational tasks, abstractness and cognitive level must be considered jointly.

The work on the taxonomy by Bloom and his colleagues did suggest the presence of a concrete-to-abstract dimension to educational tasks (Dunkin & Biddle, 1974), but this dimension was presumed by them to parallel with the simple-to-complex dimension of educational tasks. The consequence of this "parallel assumption" is that experimenters have seen no need, when studying cognitive level, to control for other dimensions of the educational task. In the decade since Solomon suggested that both abstractness and cognitive complexity be considered,

no research has been reported in which the attempt has been made either to verify that only one dimension need be considered, or to identify other dimensions which, along with cognitive level, may be having a significant effect on student achievement.

Dimensions other than cognitive complexity have been analyzed. Such learner characteristics as grade-level and gender have been controlled in earlier experiments, but only a single dimension of the educational task has been controlled at a time. Ironically, one set of research results that is consistent is that dealing with the abstractness of tasks. Research by Stoke (1929), Gorman (1961), and Paivio (1979) is uniform in its affirmation of the fact that abstract concepts are more difficult to learn than concrete concepts.

The present study operationalized Solomon's idea of a cognitive, as well as an abstractness dimension in educational tasks. It asked whether the independent manipulation of cognitive level, by altering item structure to reflect varying cognitive demands according to the Bloom taxonomy, and degree of abstractness, by controlling the key concepts used in the items, would each account for a significant amount of the variance in subjects' achievement scores. An answer in the affirmative would suggest that a second statistically significant main effect may have been ignored in earlier research.

Method

The cognitive demand of questions is commonly viewed

dichotomously as lower/higher order (Allen, 1970). The lower level question, what Bloom and his colleagues called knowledge-level, focuses on recall. A knowledge-level question asks the learner to "remember the idea or phenomenon in a form very close to that in which it was originally encountered" (Bloom et al, 1956, p. 79). Higher-order questions require students to "search through and mentally manipulate data" (Allen, 1970).

Altering the cognitive demand of an educational task is a skill which can be acquired by educators (Bedwell, 1975; Crawley & Krockover, 1979). For example, two multiple choice items could be asked about Rousseau's Emile. The first item could require the correct answer as it was presented in class:

Which of the following wrote a fictional account of the rearing and education of a boy?
a. Rousseau
b. Locke
c. Dante
d. Hobbes

The second could require the student to apply what he/she knows about Emile to a new set of circumstances:

Which of the following school situations is most consistent with the approach to education set forth in Emile?
a. The Boston Public Latin Grammar School
b. Teacher's College's Lincoln School in 1913
c. A.S. Neill's Summerhill
d. The Philadelphia Academy of the late 1700s

The abstractness of a task is a function of the concepts which are used. It can be manipulated in a testing situation by developing items which are structured alternately around concrete concepts and abstract concepts. Abstract concepts have attributes which cannot be perceived through the senses, cannot be "pointed to" (Gagne, 1974, p.

59). Abstract terms derive their meaning largely through verbal experiences (Paivio, 1979, p. 60).

Subjects

Subjects were 75 students at a major university in the southwestern United States. They were drawn from two sections of a senior level education class offered to students not majoring in curriculum and instruction. A group of (13) judges was also needed. They classified the concepts for degree of abstractness. Also teacher preparation students, they were enrolled in a different course.

Instrumentation

The manipulation of abstractness required that concrete and abstract concepts be identified. The procedures used for this were similar to those used by Gorman (1961), and Spreen and Shulz (1966). Prior to a regularly scheduled quiz during the tenth week of a sixteen-week course, the instructor's notes and related textual material were scanned for significant concepts. Those concepts relating directly to the course objectives being tested were selected. This procedure yielded a list of 70 concepts, each of which had been the subject of class discussion.

The concepts were arranged as a list of 70 items, each item in a Likert format with response options 1 through 5. Each copy of the classification instrument included directions that asked judges to classify the concepts in light of definitions of abstract and concrete which were provided

(see Table 1). Instructions to the judges explained that the selection of option 1 would indicate that the respondent felt that the concept was "concrete;" a 2 would indicate "rather concrete;" a 3 would indicate "neither clearly abstract nor concrete;" a 4 would indicate "rather abstract," and a 5 would indicate "abstract."

Insert Table 1 about here

After the concepts were classified according to relative abstractness, the eight judged to be most concrete and the eight judged to be most abstract were selected for use in the achievement instrument. Each concept became the subject in the stem of two separate achievement test items. The initial use was in a recall item; the second was in an item structured to be more demanding than recall. The cognitive level of the test items was controlled by structuring items according to procedures established by Bloom, Hastings, and Madaus (1971). This yielded a 32-item instrument with four subgroups of eight items: concrete-recall, abstract-recall, concrete-higher-than-recall, abstract-higher-than-recall. For purposes of illustration, Table 2 presents one item from each category. The length of the quiz and the type of item written (multiple-choice) were typical of other quizzes administered during the course.

Insert Table 2 about here

Analysis

The focus on cognitive level and degree of abstractness suggested the use of a two-way analysis of variance experimental design.

Results and Discussion

Mean ratings of the eight most concrete concepts were less than, or equal to 1.92. Mean ratings of the eight most-abstract concepts were greater than, or equal to 4.00. Descriptive statistics for each subgroup of items in the achievement test as well as for the test as a whole are reported in Table 3.

Insert Table 3 about here

Achievement Test Results

Relying on subgroup mean scores as a guide, it is clear that the difficulty varied substantially. Item subgroups and their accompanying mean scores from least to most difficult are as follows: concrete-recall (6.81), abstract-recall (6.15), abstract-higher-than-recall (5.73), and concrete-higher-than-recall (5.01). The total possible was eight points. The most difficult subgroup was also the subgroup in which scores were most variable.

The alpha coefficient for the instrument was calculated to

be .86. Subgroup alpha coefficents are low, reflecting the small number of items in each subgroup. If each subgroup had contained 32 items, for instance, application of the Spearman-Brown formula (Guilford, 1954, p. 353-354) suggests that the alpha coefficients that could be expected are .83, .87, .85, and .87 for item-subgroups one to four respectively.

These results indicate that item difficulty is a function of something more than just cognitive complexity. As one might anticipate, the least difficult items were those in the recall-concrete subgroup; both the abstract item subgroups posed greater difficulty. The most difficult item subgroup, however, was that composed of concrete-higher-than-recall items.

Factorial Analysis of Variance

Results of the analysis of variance appear in Table 4. These results suggest that the cognitive level of the response demanded by the item, and the relative abstractness of the item contributed significantly to the variance of test scores. Besides the significance of these two main effects, their interaction was also significant.

Insert Table 4 about here

The interaction is illustrated in Figure 1. This interaction may explain the contradictions that have emerged in earlier research. It suggests that the impact of one

dimension is not constant across all levels of the second dimension. The consequence is that students had least difficulty with concrete-recall items, as one might have assumed, but most difficulty, not with abstract-higher-than-recall items, but with concrete-higher-than-recall items. This is further substantiated by the application of a Scheffe (1959) test, which revealed that mean scores for the recall-level subgroups of items were significantly ($p < .01$) different from the mean scores for the higher-than-recall subgroups at each level of item abstractness. Consideration of abstractness and cognitive level without attending to the interaction would produce misleading conclusions.

Insert Figure 1 about here

The practical significance of these results can be considered by calculating the amount of variance accounted for by each individual variable in the design (Pedhazur, 1982, p. 55). The main effect for abstractness of the item accounted for 2% of the variance in test scores; the main effect for cognitive level accounted for 27%; and the interaction accounted for 16%. The importance of the main effect for cognitive level is readily apparent; the main effect for abstractness of item seems unimportant until the impact of its interaction with cognitive level is considered.

Conclusions

The results of this study indicate that independent manipulation of the dimensions "abstractness" and "cognitive level" can account for a statistically significant and practically important amount of variance in subjects' test scores.

It was noted in the introductory paragraphs that increasing the cognitive demand of tasks is assumed to be beneficial to learners. The study reported here neither supports nor refutes that assumption but it has implications for it. This study indicates that item difficulty is a function of more than just the cognitive level of the item. It follows then that the analysis of the impact that cognitive level has on student achievement must accomodate besides cognitive level, the effect of the abstractness of concepts, and the effect of an interaction of main effects. The suggestion is that neither cognitive level or abstractness of concepts can be ignored in descriptions of the influence that various kinds of tasks have on learner achievement.

It appears that educational tasks have been viewed too simplistically. It seems logical to ask what other dimensions of the educational task might be profitably combined with cognitive level and degree of abstractness to clarify the relationship between the task required of students and their subsequent achievement.

Table 1

Definitions of Abstract and Concrete

Provided to Concept Judges

1. Concrete concepts have perceptible attributes; the attributes of the concept can be perceived through the senses--the words are more "picturable" (Klausmeier & Allen, 1978, p. 5; Paivio, 1979, p. 59).

2. Concrete words have greater meaning in isolation. They are words which are learned without the necessity of having learned other words (Paivio, 1979, p. 60).

3. Abstract terms derive their meaning largely through verbal experiences (Paivio, 1979, p. 60).

4. Abstract concepts have attributes that cannot be directly perceived--cannot be "pointed to" (Gagne, 1974, p. 59).

5. Abstraction requires the manipulation of spatially and temporally remote events (Paivio, 1979, p. 18).

Table 2

Sample Items from the Achievement Test

Concept identified as concrete: junior high school

Concept identified as abstract: the "band wagon effect" in education

Concrete-recall

1. The junior high school was organized because of
   *a. the N.E.A. Committee of 10
   b. the N.E.A. committee on the reorganization of the school
   c. the N.E.A. Committee of 9
   d. the influence of the Cardinal Principles

Abstract-recall

2. The "band wagon effect" in educational innovation is most evident when
   a. there is an impressive build-up before implementation
   b. a propoganda campaign is waged te defeat the innovation
   *c. adoption is based on what others do
   d. the innovation generates great amounts of publicity

Concrete-higher-than-recall

3. The junior high school is a part of an organizational format in public education that is inconsistent with its support system. The format is
   a. unitary
   b. dualistic
   *c. tripartite
   d. quadripartite

Abstract-higher-than-recall

4. As it impacts education, the bandwagon effect likely
   a. discourages rapid change
   b. encourages shunning educational literature
   c. encourages an uderstanding
   *d. makes change disjointed and poorly coordinated

Table 3

Descriptive Statistics for Subgroups and for the Entire Instrument.

	Item-Subgroup				
	1	2	3	4	Total
No. of Items	8	8	8	8	32
Mean	6.81	6.15	5.01	5.73	23.71
Std. Dev.	1.30	1.69	1.91	1.75	5.60
Alpha	.56	.64	.59	.63	.86

Table 4

Factorial Analysis of Variance:

Cognitive Level by Abstractness

Source	df	SS	F	PR >	R -SQUARE
Model	225	335.90	2.07	0.0002	0.86
Between Sub.	74	49.85	.93	0.6175	
Within Sub.					
C	1	120.33	177.50	0.0001	0.27
A	1	7.05	13.94	0.0004	0.02
C x A	1	71.05	98.38	0.0001	0.16
Error	74	53.45			
Cor. Tot.	299	389.35			

Note. C = cognitive level

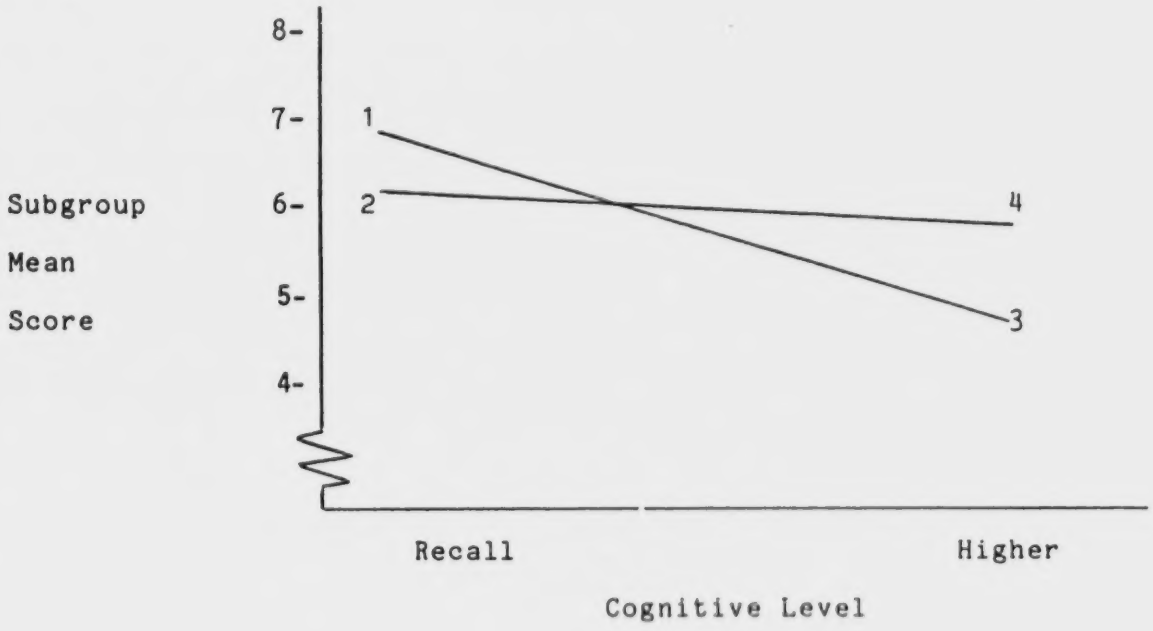
A = level of abstraction

C x A = cognitive level by level of abstraction

Cor. Tot. = Corrected Total

Figure 1

The Interaction of Cognitive Level by Level of Abstraction



Note.

1 = mean scores for concrete-recall items

2 = mean scores for abstract-recall items

3 = mean scores for concrete-higher items

4 = mean scores for abstract=higher items

References

Allen, D.I. (1970). Some effects of advance organizers and level of question on the learning and retention of written soical studies material. Journal of Educational Psychology, 61, 333-339.

Andre, T. (1979). Does answering higher level questions while reading facilitate reproductive learning? Review of Educational Research, 49, 280-318.

Bedwell, L.E. (1975). The effects of training teachers in question-asking skills on the achievement and attitudes of elementary pupils (Doctoral dissertation, Indiana University, 1974). Dissertation Abstracts International, 35, 5980A.

Beseda, C.G. (1973). Levels of questioning used by student teachers and its effect on pupil achievement and critical thinking ability (Doctoral dissertation, North Texas State University, 1972). Dissertation Abstracts International, 33, 4214A.

Bloom, B.S., Englehardt, M.D., Furst, E.J., Hill, W.H., & Krathwohl, D.R. (Eds.). (1956). Taxonomy of educational objectives: Handbook I - the cognitive domain. New York: Longman.

Bloom, B.S., Hastings, J.T. & Madaus, G.F. (1971). Handbook on formative and summative evaluation of student learning . New York: McGraw-Hill.

Buggey, L.J. (1971). A study of the relationship of classroom questions and social studies achievement of second-grade children (Doctoral dissertation, University of Washington, 1971). Dissertation Abstracts International, 32, 7543A.

Corey, S.M. (1940). The teachers out-talk the pupils. The School Review, 48, 745-752.

Crawley, F.E. & Krockover, G.H. (1979). Immediate and delayed effects of training preservice secondary science teachers to ask questions fo varying cognitive levels. Journal of Research in Science Teaching, 16, 21-26.

Dunkin, M.J. & Biddle, B.J. (1974). The study of teaching. New York: Holt, Rinehart & Winston.

Gagne, R.M. (1974). Essentials of learning for instruction. Hinsdale, Illinois: The Dryden Press.

Gorman, A.M. (1961). Recognition memory for nouns as a function of abstractness and frequency. Journal of Experimental Psychology, 61, 23-29.

Guilford, D.J. (1954). Psychometric methods (2nd ed.). New

York: McGraw-Hill.

Haynes, H.C. (1935). The realtion of teacher intelligence, teacher experience, and type of school to types of questions. Unpublished doctoral dissertation, George Peabody College for Teachers, Vanderbilt University, Nashville, Tennessee.

Hunkins, F.P. (1969). Effects of analysis and evaluation questions on various levels of achievement. The Journal of Experimental Education, 38, 45-58.

Klausmeier, H.J. & Allen, P.S. (1978). Cognitive development in children and youth: A longitudinal study. New York: Academic press.

Mamary, A. (1976). The effects of variations in the cognitive level of test items on student achievement in mathematics (Doctoral dissertation, Columbia University, 1975). Dissertation Abstracts International, 36, 5227A. (University Microfilms no. 76-3263, 86)

Martikean, A. (1973). The level of questioning and their effects upon student performance about the knowledge level of Bloom's taxonomy of educational objectives: A research paper. Gary Indiana: Indiana University Northwest. (ERIC Document Reproduction Service no. ED 091 248)

Paivio, A. (1979). Imagery and verbal processes (3rd ed.). New York: Holt, Rinehart, Winston.

Pedhazur, E.J. (1982). Multiple regression in behavioral research: Explanation and prediction (2nd ed.). New York: Holt, Rinehart & Winston.

Redfield, D.L. & Rousseau, E.W. (1981). A meta-analysis of experimental research on teacher questioning behavior. Review of Educational Research, 51, 237-245.

Sanders, N.M. (1966). Classroom questions: What kinds? New York: Harper & Row, Publishers.

Savage, T.V. (1972). A study of the relationship of classroom questions and social achievement of fifth grade children (Doctoral dissertation, University of Washington, 1972). Dissertation Abstracts International, 33, 2245-A.

Scheffe, H. (1959). The analysis of variance . New York: John Wiley & Sons.

Solomon, G. (1970). The analysis of concrete to abstract classroom instructional patterns utilizing TIP profile. Journal of Research and Development in Education, 4, 52-61.

Spreen, O., & Shulz, R.W. (1966). Parameters of abstraction, meaningfulness, and pronunciability for 329 nouns. Journal

of Verbal Learning and Verbal Behavior, 6, 459-468.

Stevens, R. (1912). The question as a measure of efficiency in instruction: A critical study of classroom practice. Teachers College Contributions to Education, no. 48.

Stoke, S.M. (1929). Memory for onomatopes. Journal of Genetic Psychology, 36, 594-596.

Winne, P.H. (1979). Experiments relating teachers' use of higher cognitive questions to student achievement. Review of Educational Research, 49, 13-50.